placed in our hands by the researches of the American geologists.

In Northern Europe, Kjerulf, Dahll, Brögger, Reusch, and other geologists have ably illustrated the same peculiarities of structure in the denuded mountain-chain near the southern extremity of which we are now assembled; and in a recent valuable and suggestive essay "On the Secret of the Highlands" Professor Lapworth has shown how perfectly these structures are exemplified in the western district of Sutherland.

In offering a few remarks on some of the still unsolved problems of Highland geology I shall not hesitate to treat, as belonging to the same geological district, both Scandinavia and Scotland. Not only is the succession of geological deposits in the two areas almost completely identical, but the characters of the several formations and their relations to one another in the one country are almost the exact counterpart of what they are in the other.

The problems which await solution in Scotland are the same which confront our brethren in Scandinavia; their difficulties are our difficulties, their successes our successes; if they share the benefits of our discoveries, we equally partake with them in the fruits of their achievements. Important links in the chain of geological evidence, absolutely wanting in the one area, may perchance be found in the other. Every advance, therefore, which is made in the knowledge of the rocks of the one country, must necessarily re-act upon the opinions and theories which prevail among geologists in the other.

At the base, and forming the foundation of this greatly denuded mountain-chain, there exist enormous masses of highly foliated, crystalline rocks. These, in great part at least, underlie the oldest known, fossiliferous strata, and are therefore of pre-Cambrian or Archæan age. In spite of the labours of Kjerulf, Dahll, Brögger, Reusch, Torneböhm, and many others in Scandinavia, and of Macculloch, Nicol, and their successors in this country, much still remains to be done in studying the petrographical characters and the geognostic relations of these widespread formations.

Some thirty years ago it was suggested by Sir Roderick Murchison that among these Archæan rocks there exists a "fundamental gneiss," a formation which is the counterpart and contemporary of the rocks in Canada, to which Sir William Logan gave the name of "Laurentian." Since that time other similar attempts have been made to identify portions of these Archæan rocks in the Highlands and Scandinavia with crystalline rock-masses in different parts of the New and Old World.

I confess that, speaking for myself, I am not sanguine as to the success of such endeavours. The miserable failures which we have seen to have attended similar attempts, in the case even of far less altered rocks, where identifications have been based on mineralogical resemblances only (and in connection with which definite palæontological or stratigraphical evidence has been subsequently obtained) ought surely to teach us caution in generalising from such uncertain data. It has been argued that, where palæontological evidence is wholly wanting, and stratigraphical relations are doubtful or obscure, then we may be allowed to avail ourselves of the only data remaining to us—those derived from mineralogical resemblances. But surely, in such cases, it is wiser to admit the insufficiency of the evidence, and to say "We do not know!" rather than to construct for ourselves a "fool's paradise," with a tree of pseudo-knowledge bearing the Dead-Sea fruit of a barren terminology! The impatient student may learn with the blind poet that

> They also serve, who only stand and wait

It is thought by some that the application of the microscope to the study of rock-masses may reveal peculiarities of structure that will serve as a substitute for palæontological evidence concerning the age of a rock when the latter is wanting. Greatly as I value the insight afforded to us by the microscope when it is applied to the study of the rocks, and highly as I esteem the opinions of some of those who hold these views, yet I fail to see that any such connection between the minute structure and the geological age of a rock has as yet been established.

Although the bold generalisation which sought to sweep all the crystalline rocks of our central Highlands into the great Silurian net has admittedly broken down, yet it by no means follows that the whole of these rock-masses are of Archæan age. Nicol always held that among the complicated foldings of the Highland rocks many portions of the older Palæozoic formations, in a highly altered condition, were included (see *Quart. Journ. Geol. Soc.* vol. xix. (1864), p. 184, and "Geology and Scenery of the North of Scotland," 1866). The same view has been persistently maintained by Dr. Hicks, to whose researches among the more ancient rock-masses of the British Isles geologists are so greatly indebted, and also by Prof. Lapworth.

To the settlement of this very important question we may feel sure that the effort of the officers of the Geological Survey will be especially directed. The geological surveyors of Scandinavia have been so fortunate as to detect, in rocks of an extremely altered character, a number of fossils sufficiently well preserved for generic and sometimes even for specific identification. Failing the occurrence of such a fortunate accident, I confess that it has always appeared to me that the disturbances to which these Highland rocks have been subjected are so extreme, and the difficulty of making out the original planes of bedding so great, that but little can be hoped for from general sections constructed to show the relations of the rocks of the Central and Southern Grampians to the fossiliferous deposits of the North-West of Sutherland.

Lying unconformably upon these Archæan crystalline rocks in our North-West Highlands we find great masses of arkose or felspathic grit, with some conglomerates, the whole of these well-stratified deposits attaining a thickness of several thousands of feet. These rocks, in their characters and their relations, so greatly resemble the "Sparagmite Formation" of Scandinavia, that it is impossible to refrain from drawing comparisons between them. The Scandinavian formation, however, includes calcareous and slaty deposits, which are wanting in its Scottish analogue. The "Sparagmites" of Scandinavia, as a whole, appear to underlie strata containing Cambrian (Primordial) fossils, but in the very highest portion of the "Upper Sparagmite Formation" of Southern Norway there have been found, according to Kjerulf, specimens of *Paradoxides*.

The Scottish formation has, on the other hand, yielded no undoubted organic remains. Murchison, on the ground of its unconformable infraposition to his Silurian strata, and its resemblance to certain beds in Wales which he called Cambrian, referred it in his later years to that system. Although an identification, based on such grounds, must be admitted to be of small value indeed, yet the discovery of "Primordial" fossils in the very similar rocks of Scandinavia may be admitted to lend it some slight support. In the present state of our knowledge, however, it is surely wiser to admit that the question of the age of these beds is still an open one, and to call it by the name suggested by Nicol—"The Torridon Sandstone." Kjerulf believes there is evidence that the Scandinavian Sparagmite, in places, passes horizontally into true gneiss, and similar appearances are not wanting in the case of our Torridon Sandstone.

(*To be continued.*)

NOTES FOR THE OPENING OF A DISCUSSION ON ELECTROLYSIS, TO BE HELD IN SECTION B, AT THE BRITISH ASSOCIATION IN ABERDEEN, SEPT., 1885, BY PROFESSOR OLIVER LODGE

I. *WHAT is an Electrolyte?* The question has two distinct meanings:

(*a*) Is a given substance an electrolyte at all; *i.e.* when alone.

(*b*) Is it the electrolyte in any particular case; *i.e.* when mixed with other substances.

In answering (*a*) remember that the fact of bad conductivity does not imply that what there is is non-electrolytic. An electrolyte is one whose conduction is wholly electrolytic. Distinction between metallic and electrolytic conduction. Obedience to Ohm's law shown by electrolytes.

Tests of Electrolytic conduction.
1. Visible decomposition.
2. Polarisation.
3. Non-agreement with Volta's series-law.
4. Transparency.

In answering (*b*) the fact of bad conductivity gives a decided negative, but substances which almost insulate when alone may conduct when mixed; *e.g.* H_2O + HCl.

To the question, What is the real conductor when a salt (or acid) is dissolved in water? there are four possible answers:

(1) The salt only,
(2) The water only,
(3) Both the salt and the water,
(4) A hydrate of the salt.

(1) is to be held by those who regard the water as unchanged by the addition of salt

(2) is to be held by those who suppose the water-molecules to be dissociated, or mechanically knocked asunder, by the massive salt-atoms

(3) and (4) are mere modifications of one another, not easily to be distinguished.

In deciding this question (*b*) we really decide what are the primary and what are the secondary products of electrolysis.

Discussion of experimental evidence bearing on the point.

Hittorf's and Buff's experiments on mixed Electrolytes.

Magnus and others on the effect of current-intensity. (With intense currents you are more likely to get the real ions liberated because secondary actions have hardly time to occur).

Direct experiment suggested by observing the place of appearance of free acid; and preliminary reply in favour of (3) or (4).

Valid objection suggested by Smee to regarding any of these experiments as crucial; but possible means of evading the objection.

Experiments of Hisinger, Berzelius and Davy on electrolytes in series sometimes throw light on the question, which are the real ions.

II. *Questions about the "migration of ions." Do ions in salt-solutions travel at different rates? And, in any case, at what rate do they travel?*

Distinction between fused and dissolved compounds.

There being simple experimental evidence that solutions often concentrate near anode and weaken near cathode, or perhaps occasionally *vice versâ*: what is the explanation?

Several possible hypotheses:

(1) Hittorf's that the salt is primarily decomposed and that its ions travel at different speeds.

(2) Hittorf's resort in exceptional cases, that per-salts are electrolysed into sub-salts and radical.

(3) Burgoin's, that a hydrate of the salt is electrolysed and that the water travels mostly with the cation.

(4) D'Almeida's, that a free acid envelop is formed around anode and is electrolysed in series with the salt.

(5) Quincke's, that opposite ions have charges differing in magnitude as well as in sign, and are therefore urged with different forces.

(6) Wiedemann's, that the entire salt molecules electrify themselves by contact with the water and are thus urged bodily either with or against the current.

(7) Kohlrausch's, that every ion has its own definite rate of propagation in a given fluid when urged by a given force; and that this rate is calculable from conductivity, concentration, and migration, data.

(8) Suggested, that opposite corresponding ions must always travel at equal opposite rates, but that in solutions the water may conduct more or less of the current.

Mode in which this hypothesis (8) can explain migration; and limitation to its explanation.

Easy calculation of total or resultant velocity of ions, but difficulty in apportioning the right fraction of this velocity to each ion in accordance with Kohlrausch's theory.

Reasons for supposing it necessary that opposite ions must travel at the same pace.

Wiedemann's, Quincke's, and Helmholtz's theories of electric *Endosmose*, and proof by Wiedemann that it is independent of "migration" phenomena.

Bearing of experiments with electrolytes in series on the question of relative migration velocities; and other suggested migration experiments.

III. *Quantitative Laws of Electrolysis.*

(*a*) Ohm's law of electrolytic conduction.
(*b*) Faraday's two laws,
 (1) The voltametric law.
 (2) The law of electro-chemical equivalence.

And (*c*) dependence of decomposition EMF on chemical combination-energy.

Nature of experimental evidence in favour of these laws.

Question whether Ohm's law will be exactly obeyed for violent currents. Very important consequences of the law, if exact for feeble currents.

Physical consequences of Faraday's two laws; to be asserted of all substances for which they are accurately true.

Law (1) asserts that no such electrolyte possesses a trace of metallic conduction; *i.e.* that electrolytic conduction and chemical decomposition are precisely correlative. In Helmholtz's words, "Through each section of an electrolytic conductor we have always equivalent electrical and chemical motion." Or again, in other words, with a spice of natural hypothesis (first due perhaps to Ampère), Electrolysis is a kind of electrical *convection* rather than conduction, each atom carrying a charge with it; and the charge conveyed by every atom of a given substance is the same.

Law (2) extends this last important statement to all electrolytes, and enables us to conclude that a definite quantity of electricity belongs to each unit of affinity of every atom of whatever kind, and that fractional portions of such atomic charges are, in electrolysis at least, unknown.

This last is a most astounding statement, for it suggests that electricity may be "atomic" as well as matter.

Calculation of magnitude of this atomic charge; enormous value of it in proportion to size of atoms (10^{-11} electrostatic units, probably, per monad atom).

IV. *Questions concerning Polarisation; and the EMF needed to send a current through an electrolyte.*

The chemical changes which go on in a circuit wholly electrolytic, or in any homogeneous portion of a circuit, are decomposition and identical recomposition, and consume no energy: accordingly no finite EMF is needed to send a current through an electrolyte *when the force is really applied to it*, and Ohm's law is obeyed by electrolytes exactly as by metals.

But at junctions of metals with electrolytes, or of electrolytes with one another, permanent chemical changes may occur, and at these places a finite EMF may be situated; and this may be either negative, when it is called polarisation, or positive, when the whole arrangement is called a battery.

Calculation of such EMFs from thermo-chemical data.

Joule's proof that the heat of chemical action is a secondary result—electric currents being the primary. The EMF (whether positive or negative) of any arrangement is obtained in volts, if the total heat produced by the chemical changes per dyad gramme-equivalent be divided by 46,000.

Total polarisation may be regarded as the sum of two kinds:

(*a*) Temporary polarisation, existing during continuance of current.

(*b*) Residual polarisation, existing afterwards.

(*b*) is caused by a more or less permanent alteration of the surface of the electrodes by the clinging or combined ions.

(*a*) is caused, according to Helmholtz's theory, by a Leyden jar action of the charged atoms straining across molecular distance of the surface of each electrode, and unwilling to part with their charges. When the ions are able to combine with the electrode, or otherwise retain their charges, this (*a*) portion is very small.

Effect of secondary actions in destroying polarisation, and rendering possible a permanent current even when apparently insufficiently propelled. Helmholtz's air-free cell.

Intense currents diminish the amount of secondary action; and also modify maximum polarisation values, raising them above their customary amounts.

V. *Mechanism of Electrolytic Conduction.*

Electrolytic conduction is certainly a convection of Electricity by atoms of matter; but concerning the mode in which the atoms make their way through the fluid there are several hypotheses:

(1) The molecular chain of Grotthus; modified and accepted by Faraday and many others, modified further by Hittorf to explain migration.

(2) The dissociation hypothesis of Clausius and Williamson; virtually accepted by Maxwell, modified by Quincke to explain migration, and shewn by Kohlrausch to explain the facts of conductivity.

(3) The electrostatic hypothesis of Helmholtz.

Because Ohm's law is obeyed, it is certain that no polarisation can exist inside a homogeneous electrolyte: in other words, there is no *chemical cling* of the atoms there, but only a frictional rub. Wiedemann's view that conductivity is inversely proportional to ordinary viscosity.

Probable independence of conductivity and tenacity of

combination. Such facts as these, if well established, render necessary *some form* of dissociation hypothesis.

A Grotthus chain of quite *equidistant* atoms might serve, instead of actual dissociation, or a momentary dissociation would be sufficient; but no hypothesis which involves a tearing asunder of molecules in the *interior* of a homogeneous electrolyte can be permitted.

Herein lies the great distinction between electrolytes and dielectrics.

Hypotheses (1) and (2) may be held in either of two forms:

(*a*) The electrical influence of the electrodes may be supposed to reach every molecule of the fluid. This was Grotthus's form of (1), and is Quincke's form of (2).

(*b*) The electrical influence of each electrode may only extend within molecular distance of its surface, while the adjustments occurring in the main body of the fluid are effected by ordinary diffusion. This was probably Faraday's form of (1) and it is Maxwell's form of (2).

Helmholtz's hypothesis (3) emphasises the (*b*) aspect of the matter by appealing to electrostatic interactions of the atoms to maintain uniformity of composition. And within a range of 10^{-8} centimetres of each electrode there is supposed to exist an ordinary electrostatic strain, like that in an ordinary dielectric condenser plate.

The great magnitude of the atomic charges explains the feebleness of the difference of potential required to effect decomposition on electrostatic principles. And the same thing suggests a mainly electrical theory of chemical affinity.

To separate an atom from its charge requires expenditure of work, hence Helmholtz's theory of a specific attraction between matter and electricity, which he uses to explain Volta's "contact-force," the charge of atoms in a molecule, frictional electricity, and many other phenomena.

VI. *Addenda.*

Calculation of EMF needed to effect decomposition—

(*a*) of a dielectric,

(*b*) of an electrolyte,

on electrostatic principles.

Suggested theory of disruptive discharge.

Possible distinction between chemical compounds and molecular aggregates.

Discussion of various phenomena from the point of view of a possible "atomic" theory of electricity.

NOTES

SINCE our last issue Dr. Harting, of the Dorpat Observatory, has announced an apparent variation in the great nebula of Andromeda, which has caused some excitement in the astronomical world. As represented in all our drawings, and, still better, in a photograph which Mr. Common was fortunate enough to obtain last year, the centre of the nebula appeared to be only moderately condensed. There was no star or stellar point. Now, on the contrary, there is a most unmistakable star of the eighth or ninth magnitude. The question is, is this a *stella nova* in the line of sight of the nebula, or has the phenomenon been produced by a new condensation in the centre of the nebula itself? Opinion inclines to the latter view, as, according to some accounts, other accompanying changes have been seen with large instruments, &c. But, on the other hand, spectroscopic evidence that the apparent nebula is not a very distant cluster is absent. By our next issue we may hope for a large harvest of telescopic and spectroscopic observations of this new object.

THE International Congress of Schoolmasters was opened in the Grand Theatre at Havre on the afternoon of the 6th instant, Mr. Goblet, the Minister of Public Instruction, presiding.

THE Severn tunnel has now been completed, and on Saturday last a train containing officials and their friends passed through it from end to end.

A CASE of Asiatic cholera has occurred at Cardiff. A labourer, loading a vessel which had recently arrived from Barcelona, drank water which had been put into a cask at that port, and which was described by the medical inspector as totally unfit to drink, having the appearance of discoloured milk, and being putrid. The man died in a few hours of Asiatic cholera.

ON August 25 and subsequent days was held in Turin the International Congress of Alpine Clubs. The principal topic of discussion was the better management of refuges erected in different parts of the Alps, new regulations for guides, and pensions to be granted to them. The honorary president was the King of Italy, His Majesty being represented by M. Loyi; the acting president was Prof. Ferrati. The readings of minimum and maximum thermometers were also collected and discussed. Several excursions took place at the close of the session.

THE German Meteorological Society met for its third congress at Munich last month. Prof. Bezold, of Munich, who delivered the address of the meeting, took for his subject "The Advances of Meteorology during the last Ten Years," dwelling mainly on the alterations made by the introduction of the synoptical method in connection with telegraphy.

THE eleventh *Bulletin* of the United States Geological Survey is a paper on the quaternary and recent mollusca of the Great Basin, with descriptions of new forms, by Mr. R. Ellsworth Call, with an introduction containing a sketch of the quaternary lakes of the Great Basin, by Mr. G. K. Gilbert.

REPEATED severe shocks of earthquake have occurred in the south-east of Lower Austria and in the north of Styria, and have been followed by further shocks in Bonia, described as moving from east to west.

WE have received Prof. Holden's account of the progress of astronomy in 1884, and Prof. Rockwood's account of vulcanology and seismology for the years 1883 and 1884, reprinted from the Smithsonian Report for 1884; also Mr. Albert Williams's report on placer mines, and mining districts, from the report of the tenth census of the United States on the statistics and technology of the precious metals.

THE programme of the technological examinations of the City and Guilds of London Institute for the Advancement of Technical Education for the session 1885–86 has been published. It contains a detailed syllabus of the examinations for the different grades on each subject, and copies of recent examination papers. It is to be obtained at the offices at Gresham College, and at Exhibition Road.

MR. G. J. SYMONS, who has examined the trees recently damaged by lightning in Richmond Park, has communicated the results of his observations to the *Times*. They are two of a group of oaks in the eastern part of the park, slightly south-west of, but very near, the White Lodge. They were fine trees, their girth at 3 feet being 11 and 12 feet respectively; the trunks are 23 feet apart, and one is nearly due north of the other. There are three other trees quite close to them (within 40 feet), which are uninjured, except by the branches which were thrown upon them. The injury to one tree, though fatal to it, is unimportant, but the other tree affords a tremendous instance of disruptive power. It appears to have been cut through horizontally at about 3 feet above the ground; the upper portion shows comparatively little injury, but the lower part is not merely stripped of its bark, but burst open in a very intense way; spikes of the stem, several inches thick and 10 to 15 feet long, stand out from the trunk somewhat like the ribs of an umbrella before it is fully opened, and grip between themselves and the centre of the trunk branches which fell from the upper part before they had time to reclose, while the ground for perhaps 200 feet around is strewn with the bark and fragments of